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COTTON PRODUCTION
IN THE LOWER DESERT VALLEYS OF CALIFORNIA

CALIFORNIA AGRICULTURAL
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CIRCULAR 508

THIS CIRCULAR is for those interested in growing cotton in the lower desert valleys of California, namely Imperial and Riverside counties. Monetarily, cotton is the most important crop grown in Imperial County; the gross value of the 1960 crop was $26,771,640 (including planting seed). Cotton ranks fourth in Riverside County, with a gross value of $8,207,500 for the 1960 crop. These figures represent the value of lint cotton only.

This circular brings together information developed by the U. S. Department of Agriculture, University of California, and cotton growers in the area on the history, soils, climate, varieties, production practices, harvesting, and ginning. Information on suggested chemical controls for insects, weeds, and diseases changes from year to year and is available in other printed material, but enough information is given here to give the reader an understanding of the pests, diseases, and weeds which occur in the area.

MARCH, 1962

HISTORICALLY...

By Marvin Hoover

Interest in cotton in the Palo Verde Valley became active around 1895. Commercial production is believed to have begun in 1909 when 1,500 acres were planted in the Imperial Valley. Results were evidently favorable as 15,000 acres were reported planted in 1910.

Early investigations on cotton production in the lower desert valleys of California by the U. S. Department of Agriculture began about 1902 near Calexico in the Imperial Valley. Later they were extended to the Coachella Valley around 1908. Cotton was among the crops tested by the University of California at the Meloland Experiment Station (now Imperial Valley Field Station) in 1912. The same was true at the U. S. Experiment Farm, Division of Western Irrigation at Bard in 1919. (Station closed in 1948 and Southwestern Irrigation Field Station, Brawley, established.)

Commercial plantings increased rapidly during the 1920's. Riverside County had 25,000 acres of cotton in 1924 with 800 acres in Perris Valley, 5,500 acres in Coachella Valley, and 18,700 acres in the Palo Verde Valley. The same year Imperial County had 66,200 with 58,400 acres in the Imperial Valley and 7,800 acres in the Bard Valley. Lint cotton yields were quite low in comparison with yields now being attained.

During the late 1920's and 1930's cot-

ton production became less profitable. The acreage dropped rapidly, fluctuating between 2,000 and 14,000 acres in Imperial County and 5,000 and 18,000 in Riverside County. Finally, cotton left the Imperial Valley completely for five years during the 1940's and the acreage in Riverside County dropped to only 556 acres in 1945. (See charts, page 30.)

Without doubt, the major reasons for cotton becoming less profitable were the problem of injurious insects in all of the lower desert valleys together with a declining market. New organic insecticides such as DDT became available near the end of World War II, affording a means of economic control of cotton insects. A renewed interest in cotton developed after a period of evaluation of these new materials coinciding with improved market conditions.

Plantings in Imperial County rose from 714 acres in 1950 to 116,400 acres in 1953. Plantings in Riverside County rose to 46,100 acres in 1953. Since then government controls through acreage allotments and marketing quotas have forced a reduction to the present acreage figures.

CLIMATE

The lower desert valleys are well adapted to producing high yields of excellent quality cotton. The long growing season, from early March to mid-November, allows adequate time for cotton to be included in a wide range of cropping patterns. The warm dry springs make for easily established stands with a minimum of seedling disease. The hot summer months make desert valley cotton superior in quality to the same varieties grown in other areas. The dry fall months allow a long picking season with little quality loss.

The climate (see table) is characterized by high temperatures which occasionally reach 125° F in midsummer. Killing frosts seldom occur after the

	Imperial Valley BRAWLEY	Coachella Valley INDIO	Palo Verde Valley BLYTHE
Mean annual precipitation	2.57	3.20	4.05
Mean annual temperature	71.9° F	73.3° F	70.6° F
Mean daily maximum temperature (highest month)	107.8° F (July)	106.8° F (July)	107.8° F (July)
Mean daily temperature (highest month)	91.6° F (July)	93.0° F (July)	91.2° F (July)
Mean daily temperature (lowest month)	53.0° F (Jan.)	53.7° F (Jan.)	51.5° F (Jan.)
Mean daily minimum temperature (lowest month)	37.5° F (Jan.)	38.1° F (Jan.)	34.7° F (Jan.)
Earliest date of first killing frost after July 15	Nov. 15	Nov. 9	Oct. 18
Mean date of first killing frost after July 15	Dec. 9	Dec. 4	Nov. 23
Mean date of last killing frost before July 15	Feb. 3	Feb. 7	Feb. 17
Latest date of last killing frost before July 15	Mar. 5	Mar. 16	Apr. 8
Highest temperature	122° F (July)	125° F (July)	122° F (July)
Lowest temperature	19° F (Jan.)	13° F (Jan.)	5° F (Jan.)

Source: Weather Bureau, United States Department of Commerce Federal Office Building, San Francisco, California, by letter May 4, 1956.

Key to Soils of Low Elevation Desert Area

Surface texture	Subsoils	Soil name (series)	Location	Adaptation
Gravelly sands and sands	Sands	Superstition	Steeper outside edges of Coachella and Imperial Valleys.	Specialty crops (trees and vineyard) in best locations, most of this series is questionable for farming.
Gravelly sands	Clay	Niland	Northeast area of Imperial Valley, generally north of Niland.	Relatively frost free, winter tomatoes, early melons, squash and similar crops. Special uses.
		Superstition	Steeper alluvial fans around edges of Coachella Imperial, and Palo Verde Valleys.	Special handling of crops on these soils may be necessary due to excessive water, fertilizer usage, and wind erosion. Adapted to many crops if carefully farmed.
Sands to loamy sands	Sands to loamy sands	Coachella	Gentle slopes between valley bottom and surrounding hills.	Same as above.
		Rositas	Wind modified; scattered but fairly extensive areas throughout Imperial and Palo Verde Valleys.	Same as above.
Sandy loam to silty clay loam	Clay loam to clay	Meloland	Scattered bodies throughout Imperial Valley.	Internal drainage restricted. Good general crop adaptation.

Very fine sandy loam to loam.....	Sandy loam to silty clay loam	Indio	Extensive in Coachella Valley	Well suited to all usual crops of the area.
Silty clay loam to clay..............	Sandy loam	Holtville	Extensive throughout Imperial, Palo Verde, and Bard Valleys.	Well suited to all usual crops of the area.
Silty clay loam to clay............	Silty clay	Woodrow	Near Salton Sea in Coachella Valley.	Field crops. Inadequate water penetration for plant use and salt removal is a common problem.
		Imperial	Large areas of northeast Imperial Valley and lesser area in other parts. Small areas in Palo Verde.	Field crops and certain vegetable crops. Inadequate water penetration for plant use and salt removal is a common problem.

middle of March or before the middle of November.

The months of July, August, and September are characterized by high relative humidity which adversely influences boll setting and contributes to an excessive amount of boll rotting.

SOILS

By A. F. Van Maren, R. L. Cowan, H. Schulbach

Cotton grows well on most soils of the lower desert valleys; these calcareous soils supply all necessary plant nutrients except phosphorus and nitrogen.

The soils (see table) are extremely variable in character, with pronounced differences in texture, structure, depth, stratification, fertility, and salinity. They were formed of mixed parent materials deposited under varying marine, lake, semi-lake, delta, stream, or alluvial fan conditions. Some soils have been further modified by winds.

Topographic conditions existing when the soils were being deposited allowed considerable particle size separation and, therefore, stratification. Because of the variations in soil characteristics, crop growth differences occur frequently.

Salinity is a problem in many fields. Although cotton is tolerant to salt, it does best on nonsaline soils and the yield is reduced in proportion to the amount of salt present.

Soils of the four growing areas (Bard, Coachella, Imperial and Palo Verde valleys) are similar in some respects but dissimilar in others. Because of these differences, soil management and cultural practices should be tailored to the soil conditions in the particular field. *What is best for one field may not be best for others.*

VARIETIES

By P. H. van Schaik

Only three varieties have been grown commercially in the past ten years to any extent. **Acala 4-42,** developed and grown exclusively under the one-variety law in the remainder of California, automatically became the variety for the lower desert valleys. Desert valley-grown Acala 4-42 soon gained a reputation for being one of the highest quality cottons in the country. Much of it was used for blending with American-Egyptian type cotton for manufacturing high-quality goods.

In 1953 some **Deltapine-15** was introduced. This variety gained rapidly in popularity, and by 1958 accounted for approximately 95 per cent of the Imperial County acreage. In 1960 the Palo Verde Valley was the only desert valley where Acala 4-42 was the predominant variety. Deltapine-15 found wide acceptance because of its adaptation to a wide range of soil conditions and cultural practices and its ability to set a heavy crop, particularly during the early part of the fruiting season.

The table on page 7 shows the average performance of DPL-15 and A4-42 in tests conducted over a seven-year period at several locations in the three desert valleys. The data show DPL-15 to be superior in lint yield and A4-42 to be superior in fiber length and fineness, and in fiber and yarn strengths.

Under present cotton marketing systems, with little or no price differential for quality fiber, growers have changed to the variety which gives them the greatest yield.

The newly released **Deltapine-Smooth Leaf** variety has supplanted Deltapine-15 almost completely in Imperial and Coachella valleys and accounted for about 90 per cent of the cotton acreage in the Palo Verde Valley in 1961.

Coker 124 was grown on a limited acreage in 1957 and 1958 but did not persist in subsequent years.

A considerable acreage in the Palo Verde and Bard valleys has been planted to the Arizona variety **Acala 44.** This variety, in general, is comparable in yield and fiber characteristics to Acala 4-42 but has considerably less stalk stiffness.

A small acreage in the Palo Verde and Bard valleys is also planted each year to the extra long staple **Pima** varieties. This cotton is hauled into Arizona for roller ginning.

Varieties and experimental strains are being tested continuously by the University of California and U. S. Department of Agriculture Experiment Stations. Results from these tests are reported each year during field days and meetings when progress in varietal improvement and other research is discussed.

Yield, Fiber, and Spinning Comparisons of Deltapine-15 and Acala 4-42 in Desert Valleys of California

Properties	Deltapine-15	Acala 4-42	Comments
Yield			
(lbs. of lint per acre)	1730	1515	14% in favor of DPL-15
Classification			
grade	Middling	Middling	
staple (inches)	1 1/32	1 1/16	A4-42 1 1/32 to 1 3/32 DPL-15 1 1/32 to 1 1/16
Raw Cotton			
fibre length (inches)	1.07	1.11	Measured by Fibrograph instrument, which is more accurate than classer's staple length.
Fibre strength (lbs./sq. inch)	84,000 (average)	99,000 (very strong)	Strength is very important in determining end use of fiber. Strong cotton produced in few areas in the Cotton Belt.
Fiber fineness (micronaire)	5.0 (medium coarse)	4.3 (medium fine)	Finer fibers usually longer and stronger, lower micronaire usually more desired together with length and strength.
Yarn properties			
strength of 22's (lbs.)	122	142	Higher value refers to stronger yarns; 22's and 50's indicate yarn number used in spinning process. Important in determining quality of fabric woven from yarn.
strength of 50's (lbs.)	44	52	
neps (per 100 sq. inches)	9	10	Neps are small knots or tangles of fiber. Affect yarn appearance and ability of yarn or fabric to take dye. Both varieties low in neps.
yarn appearance index	101	100	Indicates quality of finished fabric. Both varieties good.
picker and card waste (%)	9.01	8.42	Waste extracted in processes of spinning. Excessive waste causes increased manufacturing costs. Both varieties average.

PRODUCTION

LAND PREPARATION

By A. F. Van Maren,
Herbert Schulbach

Proper land preparation serves to increase water penetration, control weeds and pests, incorporate crop residues, and to prepare a seed bed. It should begin immediately after harvesting the previous crop.

Land preparation influences the growth characteristics of the crop through its effects on irrigation, root development, fertility, and soil compaction. Improper or excessive tillage reduces yields.

Deep subsoiling in stratified soils may be beneficial if the soil is sufficiently dry to allow permanent separation of layers. Check soil moisture conditions to the depth of operation and if the soil is so wet that smearing rather than shattering occurs, subsoiling should not be done.

Plowing to a depth of 10 to 12 inches is preferred. Plowing is the most successful method to turn under crop residues. When sufficiently dry, a field should be disked once or twice, then irrigated so the water can help to decompose crop residues.

Floating is not necessary unless a field is cloddy. An extremely fine seedbed may result in germination, subbing, crusting, or cracking problems.

When cotton is to follow cotton, residues of the previous crop should be shredded to hasten decomposition and to reduce the survival of insects and plant pathogens. Following these basic land preparations, a preplant fertilizer application should be made. This may be broadcast, banded in the bed, or injected.

Preirrigation of listed beds is optional depending upon whether a grower prefers to plant in moist or dry soil.

FERTILIZERS

By A. J. MacKenzie, A. F. Van Maren, and R. L. Cowan

The soils of the lower desert valleys are inherently low in organic matter and **nitrogen content,** and because of this, nitrogen is likely to be the most important nutrient limiting growth. By using adequate amounts of fertilizer nitrogen high yields can be obtained.

The need for **phosphorus** in the area is not as well established as that for nitrogen. Soils of the area vary in phosphorus fertility levels depending upon past fertilizing and cropping practices. Although phosphorus fertilizers are commonly applied to cotton, yield increases seldom result.

Other nutrients, such as potassium, calcium, magnesium, sulfur, and the essential trace elements, are available in sufficient amounts in the soils or irrigation water of the areas. Fertilizer tests have shown no benefits from application of these nutrients.

In considering fertilizer needs, carryover nutrients from the fertilization of previous crops may be present in sufficient quantities to feed a cotton crop. This is most likely to be the case with phosphorus if the land has been used recently for alfalfa or a vegetable crop. In such cases additional phosphorus may not be necessary. On land which has a long history of crops receiving little or no phosphorus, phosphorus fertilizer should be applied preplant. Forty to 80 pounds of P_2O_5 per acre, broadcast before bed listing, or side-dressed in the seedbed, is sufficient.

Cotton needs considerable **nitrogen** for maximum production. For a three- to four-bale per acre crop the plants will use 200 to 240 pounds of nitrogen per acre during the season. About half of this nitrogen goes into the leaves and stems and the other half is contained in the squares and bolls.

During the first 45 days of growth cotton uses very little nitrogen. As the plants approach the square and early blossom stage nitrogen uptake increases markedly. The peak rate of nitrogen use occurs between 75 and 135 days after planting during which time up to 3 pounds of nitrogen per acre per day may be used. Thereafter, the demand for nitrogen decreases, and very little is used in the latter part of the season.

The nitrogen contribution by the soil is usually far short of the total needs of a cotton crop. For soils low in nitrogen, application of 200 to 240 pounds of nitrogen per acre is necessary. If nitrogen losses occur during application, as with ammonia-type fertilizers in the irrigation water, or if leaching is a problem, a higher rate will be needed. On the other hand, the rate can be reduced if cotton is planted in soils which contain appreciable quantities of residual nitrogen.

The exact quantity of fertilizer nitrogen needed by cotton to insure high as well as economical production is affected by such factors as varieties, soil moisture, nitrogen losses, salinity, and the control of pests, diseases, and weeds. High fertilizer efficiency can be obtained only if all operations involved in cotton production are kept at optimum levels.

As an aid in arriving at the proper amount of fertilizer nitrogen to apply to cotton, plant tissue tests can be helpful. The nitrate-nitrogen composition of the petioles of the youngest, fully matured leaves on the main stem of the plants is a good indicator of the nitrogen fertility status of the plants. Periodic sampling during June and July and analysis of the petioles will assess the nitrogen level of

> Excessive use or late application of nitrogen should be avoided. These practices promote rank growth, lodging, delayed maturity, and other undesirable conditions and hinder defoliation and efficient harvesting.

the crop and determine if additional nitrogen is needed to insure maximum production. To insure maximum production, petiole nitrate-nitrogen should not drop below 2,000 ppm before the end of July. Excessive applications of nitrogen also can be avoided by the use of this test. Tissue testing services are available through commercial laboratories.

When to apply

As mentioned previously, the maximum rate of nitrogen uptake occurs between 75 and 135 days after planting. It is important, therefore, to have sufficient nitrogen available to the plants prior to and during this stage of growth in order to assure good production and fertilizer applications should be timed with this in mind. In general, on fine-textured soils, one-third of the nitrogen should be applied before or at planting time and the remaining two-thirds at thinning time or by early June. On sandy soils more frequent, smaller applications are better because of possible nitrogen losses. These applications may be continued through July without detrimental effects. The objective in all cases, however, should be to apply the needed nitrogen as soon as possible.

The choice of the source of nitrogen will probably depend upon price and the method of application used. If applied correctly, all common forms of nitrogen fertilizer will be equally efficient on cotton.

Recently the use of cheaper fertilizer materials containing free ammonia has increased. Such materials should be injected. Preplant injections of ammonia-containing fertilizers should be placed well away from the seedrow to prevent injury to the seedlings. Young cotton is sensitive to ammonia and will be severely injured if the ammonia is injected too close to the plants.

The objective of fertilizer placement is to get the plant food into the root zone where it will be easily accessible to the plant. At planting time, place the fertilizer at least 6 to 8 inches from the plants on either or both sides of the row and 4 inches below the seed level. For later applications to established plants, place the materials far enough to the side of the row (8 to 10 inches) to minimize mechanical and fertilizer injury to the plant roots.

PLANTING

By P. H. van Schaik

Date of Planting

The most favorable planting time varies with seasons and locations, but in general planting should be delayed until soil temperatures are favorable for quick germination and emergence of seedlings. There is little difference between planting in the mulch or irrigating up; in either case, a soil temperature of at least 60°F. at a depth of 8 inches is desirable. Highest yields are obtained when plantings are made during late March or early April. Poor stands often result when cotton is planted much before mid-March. Soils are generally too cool during February and early March, resulting in slow germination and weakened seedlings which are subject to attack by disease organisms.

Late May, June, and early July plantings begin to flower during the time of highest temperatures, maximum shedding, and highest populations of damaging pests. They may encounter fall frost before the crop is fully mature.

Yields obtained in date of planting experiments in Imperial Valley were:

Date of planting	Yield, bales per acre*
March 15	2.14
April 1	2.37
April 15	2.39
May 1	2.09
May 15	1.61
June 1	1.65
June 15	.71
July 1	.74

* Acala 4-42, Imperial Valley 1953–1958.

Seed Treatment

The necessity of early planting to obtain maximum yields is not as great in the lower desert valleys of California as it is in areas where the growing season is short. Because of the long growing season, growers can generally delay planting until soil temperatures are optimum for germination. For this reason, fungicidal treatment to reduce seedling diseases is not essential; however, the use of the proper fungicide can protect cotton stands from a high incidence of seedling diseases, e.g., those caused by *Rhizoctonia* and *Pythium* during cool periods which sometimes occur after planting.

Seed treatment with a recommended insecticide for control of the corn seed maggot is also important. In the lower desert valleys this pest is probably of greater importance most years than are seedling diseases.

Seed treatment service is usually available through seed organizations or delinting plants.

Systemic insecticides have been tested as seed and soil applications at planting time and as a soil application in June. While applications may temporarily control spider mites, including those resistant to most other organophosphorous compounds, placement on or near the seed may result in stand reduction. Applications at planting time and in June have been found to reduce yield in some areas or soil types while increasing yield in others. This effect is not believed to relate to pest control. Because of the variable results obtained with these materials, no recommendations can be made at this time.

Planting Methods

Most of the lower desert cotton is planted on beds, but a considerable acreage, particularly in the Coachella and Palo Verde valleys, is planted flat and furrowed out after emergence and just before the first irrigation.

Two irrigation practices are commonly used, preirrigation with planting in the moist soil, and planting in dry soil and irrigating up. The most suitable practice depends on factors such as moisture-holding capacity of the soil, condition of the seedbed, and salt accumulation in the soil. If the soil is known to crust easily or crack, or if weeds are a serious problem, irrigating up may not be a desirable practice. Irrigating up may aggravate losses due to seedling diseases in a cool year by lowering the soil temperature with the irrigation water. Where salt accumulation in the soil is a problem, irrigating up may require the use of sloping beds or alternate row irrigation to avoid salt accumulation in the center of the seed row. Planting in moist soil often causes a delay in emergence because less water is available for absorption by the seed.

Seed should always be planted in a firm, well-prepared seedbed at a depth of 1 to 2 inches. Deeper plantings may sometimes be justified to conserve moisture for good germination if part of the soil covering is removed several days after planting. When irrigating up planting at depths less than 1 inch may often be satisfactory.

Plant Population

The amount of seed needed to obtain the desired stand depends on the type of seed used, the average per cent of germination of the seed, and the emergence expected. Usually a higher planting rate is used with machine-delinted than with acid-delinted seed. A planting rate of 20 pounds of machine-delinted seed of relatively small-seeded varieties such as the Deltapines, with an emergence of 80 per cent, will give approximately 6 to 8 plants per foot of row. Comparable rates with acid-delinted seed will increase the plant population. Large-seeded varieties, such as most Acalas, will naturally require proportionately larger amounts of seed to obtain the same stand as the small-seeded varieties.

As a general rule, 15 to 25 pounds of seed per acre is ample to give an excellent stand. This allows for some loss due to weather, diseases, and pests, and permits thinning to the final stand desired.

The plant population which will give maximum yields depends on soil and climatic conditions and whether excessive rank growth is expected. Harvesting methods also must be considered. Where excessive plant growth is not expected, populations of 50,000 plants per acre (approximately 2- to 3-inch spacing) will perform best. On soils where cotton is known to grow tall and rank (as is often the case in the Coachella and Palo Verde valleys) it is desirable to hold populations down to 6- to 10-inch spacings.

Plant spacing experiments have shown that total yields are seldom affected by any spacing up to 12 inches. However, the tendency of closely spaced plants to grow tall and rank aggravates lodging and boll rot problems, and causes difficulties in harvesting.

Plants widely spaced in the row tend to form longer fruiting branches lower on the plants. The suppression or restriction of the development of the lower fruiting branches in closely spaced plants may be an advantage in machine harvesting of the crop if rankness and lodging do not become problems. Bolls located close to the ground are often left by the picking machine. Height of fruiting, in addition to being influenced by plant spacing, is also a varietal characteristic. The Acala varieties generally fruit higher off the ground than Rainbelt-developed varieties.

Taking all factors into consideration, 4- to 6-inch spacing appears to be best for maximum yield and picking efficiency.

WEED CONTROL AND CULTIVATION

By W. H. Isom and R. L. Cowan

Weeds in cotton interfere with picking operations. Weedy or trashy cotton is more difficult to gin, and the grade of lint may be lowered. The control of weeds should be an integral part of every cotton farming operation. *Each weed that lives to maturity has the capacity to reproduce by hundreds or even thousands the following year.* Successive generations of weeds compound the weed problem.

Weeds compete with cotton plants for space, nutrients, water, and light. Weeds harbor pests that may be destructive to cotton directly or indirectly. Irrigation difficulties may result from weeds clogging furrows. Air stagnation and increased humidity conditions conducive to boll rot development, are favored by excessive weed growth. Weeds also decrease the efficiency of pesticide and defoliant applications.

Cotton is cultivated primarily for weed control; there are other conditions, however, which require cultivation. After thinning and hoeing, cotton beds need rebuilding to facilitate irrigation. Open, unobstructed furrows and high beds make irrigations easier. Well-shaped cotton beds at lay-by hold up better through the remainder of the season and help mechanical harvesters stay on the row. Fine-textured soils may require cultivation to prevent drying and cracking of the surface soil.

Cultivating cotton more frequently than needed to accomplish the above objectives is useless. Instead of increasing soil aeration and permeability, excessive cultivation or working the soil too wet destroys soil structure and causes compaction. Deep, frequent cultivations prune off many of the active feeder roots of the cotton plants and therefore are detrimental.

Cultivation is the principal means of weed control in cotton. Each cultivation destroys weeds by uprooting some and smothering others with soil. Cultivation for weed control may continue after each irrigation until the cotton plants become large enough to be injured by the cultivator. Cultivations should be shallow and not too close to the cotton plants to avoid

damage to the cotton. The effectiveness of a cultivation is enhanced by permitting the disturbed soil to dry out before an irrigation is applied.

Hoeing is generally needed to supplement mechanical cultivations for weed control. Large, tall-growing weeds which have escaped the cultivator must be removed by hoeing or pulling. Hoeing is most frequently needed early in the season to remove in-the-row weeds which cannot be eliminated by other means. Hoeing is usually done in conjunction with thinning.

Rotation with winter crops such as barley and lettuce tend to reduce the weed problem in cotton. Clean-cultivated winter crops and tall-growing summer crops which shade the ground too much for weeds to grow are good crops to rotate with cotton. Crop rotation without weed control in the alternate crops, however, is not effective.

Weed control by **flame cultivation** is a widely accepted practice in some cotton-growing areas. Flame cultivation should be done soon after the weeds emerge but never before the cotton plants are at least 8 inches tall. Control the weeds by hand, mechanical cultivation, or chemicals until the cotton is large enough to withstand flame. Success of the practice depends upon the differential ability of cotton plants and weeds to withstand the flame; weeds should be small and cotton plants large. Proper flame adjustment, timeliness of application, and well-shaped beds are necessary.

Chemicals offer a bright ray of hope in the control of weeds. At the present time, however, chemical weed control in cotton is in its infancy. Before using chemicals for weed control the relative costs of the different means of control, and the residual effects of the chemicals on succeeding crops should be considered.

Four chemicals are currently recommended for weed control in cotton by the University of California. These are Dalapon, Monuron, Diuron, and selective weed oil. Dalapon is for spot treatment of troublesome perennial grasses; Monuron and Diuron are applied for annual weed control at lay-by. Selective weed oil is used on emerged weeds.

> Care should be exercised in the use of all chemicals. No chemical is foolproof; recommendations for chemical use should be strictly followed.

The use of chemicals for pre-emergence weed control in cotton is being investigated. As these materials become available commercially specific recommendations for their use will be made.

A weed control guide is published by the Agricultural Extension Service. This guide is revised annually to include research results on chemicals and methods of weed control and is available at the local University of California Farm Advisor Office.

IRRIGATION

By K. Stockinger and H. Schulbach

Irrigation is one of the most important phases of cotton production but unfortunately often receives the least amount of attention. Many problems associated with poor stands, disease, and reduced yields may be directly attributable to poor irrigation practices. Because soil and climatic conditions and cultural practices vary widely, each field should be considered individually. *There is no one single recommendation for irrigation which will meet the requirements for all conditions.*

The availability and supply of soil moisture govern the rate and type of growth and the availability of plant nutrients. Well-scheduled irrigations allow maximum cotton production on plants that can be machine-harvested.

Furrow irrigation is recommended for cotton in the lower desert valleys. It results in more uniform water distribution and provides adequate aeration on

fine-textured soils when they are irrigated frequently. **The basin and border methods** of irrigation have been used successfully under some conditions.

Cotton requires 35 to 40 inches of water per acre per season to take care of transpiration and evaporation losses. Losses due to deep percolation and surface drainage will usually raise the figure to more than 40 inches.

The Need for Water

It is important to understand changes in the cotton plant associated with variations in moisture levels. As the supply of soil moisture becomes exhausted and water becomes less available to the plants, vegetative growth slows down; the field changes color from a bright to a dark or dull bluish-green; blooms are much more noticeable and appear to be concentrated in the top of the plants. It is recommended to irrigate when these changes begin.

At this time the plants may show some wilting in late afternoon, particularly on saline spots in the field. Additional delay in irrigation results in the plants wilting earlier in the day. Growth ceases and no new squares are set. Severe water stress will cause premature cracking and opening of bolls, shedding of squares and small bolls and finally leaves. Returning to a normal irrigation schedule after cotton has been severely stressed may result in rank vegetative growth because it requires nearly a month for the plants to start a set of new squares and get them to the bloom stage.

In addition to reduced yields, there are other abnormal effects from permitting cotton plants to wilt. Undesirable vegetative growth and misshapen bolls may result. These bolls may be small and contain fewer seeds. The fiber produced will be shorter, weaker, and less mature.

Excessive irrigation is also harmful. Shortening the interval between irrigations or keeping the water on for long periods of time results in more vegetative growth with no additional yield. *An excessive period of time is usually more than 24 hours.* Frequent irrigating does not reduce yields directly, but the increased vegetative growth resulting may increase the incidence of boll rots.

This excess vegetation may also result in lodging and, at the end of the season, difficulty in defoliation and harvesting. Holding the water on the soil for long periods is harmful, because it interferes with root respiration. Too much water causes the plants to become yellowish-green in color and appear nitrogen-deficient. In severe cases plants shed leaves or the leaves become blotched. The appearance of the plants is similar to fusarium or verticillium wilt-infected plants. To prevent this irrigation should be completed in 24 hours or less.

Tensiometers properly installed and cared for are good indicators of the need for irrigation. Growers should consult with the Farm Advisor on the use of these instruments. As a rule, from early July until the end of August the interval between irrigations as shown by tensiometers is remarkably constant, and a schedule may be adequate. The interval for most soils in the Imperial Valley ranges from 8 to 12 days. For the deep, medium-textured soils of the Palo Verde and Coachella valleys the interval can be lengthened to about 14 to 16 days.

The timing of the first irrigation after emergence is difficult to schedule. It depends on soil temperature and weather conditions as well as the need of the cotton plants for water. Irrigation cools the soil so irrigating during or just before a cool spell results in a cold soil which inhibits growth and promotes seedling diseases such as sore-shin. The first irrigation should not be delayed, however, in an attempt to get a deep root system. It has been shown that this practice has little effect on the depth of rooting but can slow the growth of the cotton plant, delay flowering, and reduce the early boll set.

The first irrigation will usually be made shortly after thinning or about 3 to 6 weeks after planting if soil and air temperatures are warm enough. Plant growth is stimulated by an early irrigation even when much available soil moisture remains. This occurs because the cotton roots are not well developed. Soil temperatures should be at least 75° F at a depth of 6 inches.

After August it is time to plan for the last irrigation. Where irrigations are required until October 1st, the interval between irrigations should be lengthened. Irrigation should be discontinued in time to allow the cotton plants to cut out by defoliation time. Late irrigations cause regrowth, slow boll opening, and poor defoliation.

DISEASES

By J. R. Breece

Seedling diseases. Seedling diseases of cotton can cause poor germination and damping off which may result in an inadequate stand. Although cotton seedling diseases may take their toll of seedlings even under the best growing conditions, growers frequently create conditions unfavorable for seedling growth and favorable for the disease-causing organisms. Planting too early in the season when the soil is cool, holding water on too long, improper drainage, and untimely first irrigation create adverse conditions for seedling growth.

Seedling diseases are caused by the soil fungi, *Pythium ultimum* and *Rhizoctonia solani*. Seed rot and pre-emergence damping off are mainly caused by the water mold, *Pythium*. This disease usually represents no serious problem in the lower desert valleys. *Rhizoctonia* most frequently causes post-emergence damping off. This disease is characterized by reddish-brown, sunken lesions on the stem near the soil line, hence the name "sore shin."

Some fields seem to be a haven for seedling diseases. This may be due to a high incidence of pathogenic fungi resulting from the grower's past cultural practices on a particular soil type, e.g., *Rhizoctonia* is usually more severe following alfalfa, sugar beets, and cotton.

Soil temperatures in the lower desert valleys are usually high enough by April for rapid seed germination which helps to ward off seedling diseases. Cotton seed sold commercially is usually treated with one of the mercury fungicides which are effective if applied according to the manufacturer's directions. *Seed treatment will not guarantee a good stand*, but it will help and is relatively inexpensive.

Irrigation also plays a role in seedling diseases. Water held on a field for a long period of time will cause seed to rot and seedlings to drown. Good drainage in all parts of a field is important in establishing and maintaining a stand throughout the growing season.

Soil crusting in some cases is more important than seedling diseases. Crusting will not only prevent emergence but can cause serious damage to seedlings once they have emerged. Whipping action caused by high winds can be particularly harmful in a crusted soil.

Texas root rot is caused by *Phymatotrichum omnivorum*, a soil-borne fungus. Ozonium root rot, cotton root rot, and *Phymatotrichum* root rot are other names for this disease which attacks over 2,000 broad-leaved plants. Cotton plants are very susceptible to Texas root rot. The fungus persists in the soil and reappears in the same area year after year.

Plants are infected by the fungus during the hot summer months only.

Infected plants first show a slight yellowing or bronzing of the new leaves which remain attached to the plants. The entire plant suddenly wilts due to rotting of the roots, and dies in 2 or 3 days. Brown fungus threads may be seen on the decaying roots. Tan spore mats of the fungus may appear on the surface of the soil following an irrigation or rain.

Since the Texas root rot fungus persists in the soil even at great depths, there appears to be little hope of eradicating it by fungicides or fumigation. Some suppression of the fungus by heavy applications of manure or incorporation of green manure crops (papago pea) has been shown in other areas. Planting nonsusceptible crops (grasses, corn, sorghums, cereals) in infested fields would be the best approach.

Boll rots are the most serious diseases of cotton in the lower desert valleys of California. Severe boll rots can reduce yields and degrade the quality of lint. They weaken and stain the lint, prevent bolls from maturing and opening properly, and lead to shedding of cotton locules. The prevalent boll rots in the area are black boll rot caused by *Aspergillus niger* and yellow stain lint rot caused by *Aspergillus flavus.* Pink boll rot caused by *Fusarium moniliforme*, a grey boll rot caused by *Nigrospora oryzae*, and another caused by *Rhizopus nigricans* also occur to a lesser degree.

During the months of July, August, and September the relative humidity is high, and often approaches 100 per cent in cotton fields, making conditions ideal for boll rots. Reducing humidity within the field by bottom defoliation and less frequent irrigations helps decrease the incidence of boll rots. Proper nitrogen fertilizer rates are also useful.

Leaf crumple has been found in the Imperial, Palo Verde, Coachella, and Bard valleys. The disease is identified by the downward cupping and puckering of leaves, shortening and slight thickening of leaf veins, and crinkling of flowers. This virus disease is transmitted by a whitefly. *Bemesia tabaci.*

Experimental and observational data over the past several years indicate that a severe attack of the disease may reduce seed cotton yields 20 per cent or more. In general, yield loss is much more marked when infection occurs in May, June, or early July than later in the season.

Leaf crumple is most prevalent in stub (ratoon) cotton. Because cotton is the only known host for the virus, and infected plants do not recover from the disease, stub cotton acts as a reservoir for the virus and an overwintering host for the whitefly. Whiteflies that feed on stub cotton transmit the virus to spring-planted cotton.

Elimination of cotton plants during the winter effectively reduces the source of both the virus and the insect vector the following year.

SPECIFIC DISEASE CONTROL INFORMATION is included with the pest control program outlined in Leaflet 83, "Pest and Disease Control Program for Cotton," available at the local office of the University of California Farm Advisor.

PESTS

By H. T. Reynolds, A. S. Deal,
V. D. Roth, George D. Peterson, Jr.

Many insects attack cotton. Those discussed in the following pages are the most important in the lower desert valleys. Specific recommendations for their control are given in Leaflet 83, "Pest and Disease Control Program for Cotton," published by the University of California Agricultural Experiment Station and Extension Service. This guide is revised annually to include the results of research on pesticides and methods of pest control. Copies are available at Farm Advisor Offices.

Seed-corn maggot, *Helemyia cilicrura*, is the larva of a small light gray fly about 3/16 inch long. The flies are attracted to decaying vegetation or manure where they lay their eggs. The organic matter serves as food for the larvae or maggots which hatch from the eggs. Cotton seed is often attacked when it is planted soon after harvesting lettuce, cabbage, broccoli, or other crops which leave large quantities of organic matter in the soil. Several maggots may feed in one seed and often the seeds are entirely hollowed out leaving only the seed coat. The result is a very poor stand. Many of the plants which are able to emerge from the soil may be weak because of the damage done to the cotyledons. The only effective control for seed-corn maggot is seed treatment.

Cutworms. The black cutworm, *Agrotis ipsilon*, the variegated cutworm, *Peridroma saucia*, and other species attack seedling cotton. Stems of the young plants are often cut off just above and occasionally below the soil surface. Sometimes the cotyledons may be pulled partially or completely beneath the surface of the soil and eaten. Cutworm damage may be detected by looking for wilted plants during the morning hours. Digging with a pocket knife or stick around damaged plants will usually reveal the worm an inch or two beneath the soil surface. Cutworms often occur in fields planted following alfalfa, or where fields have been allowed to become weedy before the cotton is planted.

Cutworms are difficult to control because of their habit of spending a great deal of time beneath the soil surface. These insects often crawl out on the sur-

All drawings of pests by Dr. Lemac Hopkins, of the Arizona Agricultural Experiment Station.

face during the night and may be killed with insecticides applied either as baits, dusts, or sprays. Sprays applied with ground equipment with nozzles set to spray a band 4 to 6 inches wide along the crop row are preferred. Irrigation immediately following treatment frequently helps drive the worms to the surface where they will contact the insecticide.

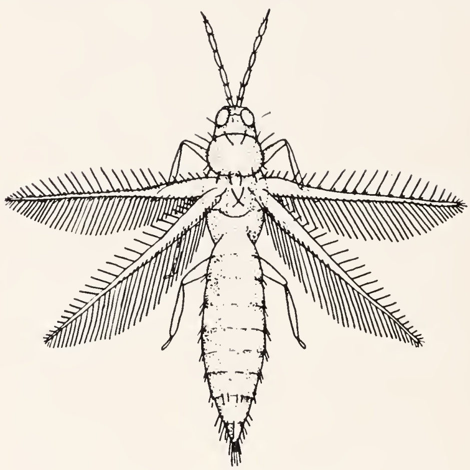
Keeping fields free of weeds and cover-crops for at least three weeks prior to planting cotton may minimize the cutworm problem.

Darkling ground beetles, *Blapstinus* spp., are occasional pests of seedling cotton. The beetle larvae collect around germinating cotton seeds and may feed on the inside of the seed coat and either on the surface or inside the seedling stem. The adult beetles usually feed on the stem at the soil surface and may girdle or completely cut off the plant. Seed treatments used for control of the seed-corn maggot will help control darkling ground beetle larvae. Insecticide treatments to the soil surface along the plant row will control the adult beetles.

The beet armyworm, *Spodoptera exigua,* frequently attacks seedling cotton plants. The adult female moth lays from 20 to 40 eggs in a cottony mass on the cotyledons or the first true leaves. The eggs hatch in a few days and the small worms begin feeding on the leaf. Small beet armyworms characteristically form a sheet-like web over the area where they feed. If not controlled, they may severely skeletonize the leaves, defoliate the plants, or even destroy the terminal buds and kill the plants.

The beet armyworm has not been a damaging pest of older cotton in past years; however, it has become more important during recent years and may become a serious pest under certain conditions. Research and experience of commercial applicators have demonstrated a rather high level of resistance by beet armyworms to the chlorinated hydrocarbon insecticides in the Imperial Valley. During 1959 and 1960 some cotton fields, which had repeated applications of insecticides early, became infested with beet armyworms from mid to late season. When such heavy armyworm populations occur, control is recommended.

Thrips. Flower thrips, *Frankliniella* spp., and the onion thrips, *Thrips tabaci,* are known to feed on seedling cotton in the lower desert valleys. These insects feed on the underside of the cotyledons, the true leaves, and in the leaf buds. Their feeding causes a characteristic silvering or scarring of the undersurfaces of the cotyledons and leaves and causes new leaves to appear ragged, cupped, and curled up at the edges.



Frankliniella thrips, adult.

Although thrips often cause plants to look unthrifty, the cotton will recover without loss in yield or quality of lint. For this reason, the control of thrips is not recommended on cotton in the lower desert valleys.

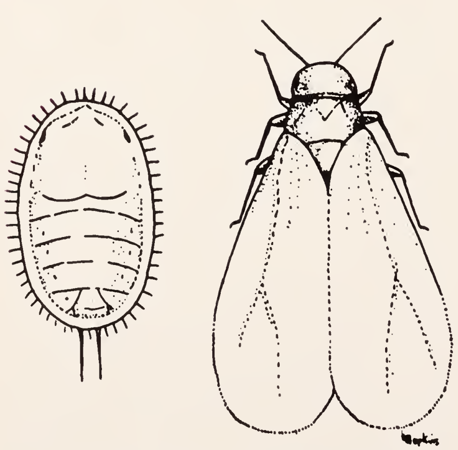
Aphids. The cotton aphid, *Aphis gossypii,* is occasionally a problem in early spring and again in late summer. Infestations can be kept from becoming widespread by spot treatment. Near harvesttime the cotton aphid may become so numerous in widely scattered areas of a

field that the honeydew deposited on the fiber reduces its quality and interferes with picking, ginning, and spinning. Usually organophosphorous insecticides used for control of other insects will hold down the aphid population.

Whiteflies. The scale-like nymphs of whiteflies, primarily *Trialeurodes* spp., are sometimes found in large numbers on the lower surfaces of cotton leaves, particularly around the margins of fields. The adults are about $\frac{1}{16}$ inch long, and the wings are covered with fine, white, powdery wax. They may often be found in large numbers laying pearly white eggs on the lower surfaces of the leaves. When present in large numbers, the lower surfaces of the leaves may appear powdery as a result of deposits of wax from the wings of the adult whiteflies.

Mechanical injury from whiteflies feeding on young plants is usually not serious; however, one species, *Bemisia tabaci*, is known to carry the leaf crumple virus. In some years heavy populations of whiteflies may persist into mid-season. If the bottom bolls are beginning to open the lint may be injured by the honeydew secreted by the whiteflies, or the molds that develop in the honeydew.

Whiteflies are difficult to control with insecticides. Normally they are controlled by a very small, yellow wasp parasite. Since insecticides are usually harmful to the parasites, chemical control measures may cause an even more serious whitefly problem and, therefore, are rarely recommended.



Nymph (left) and adult whitefly.

Leafhoppers. The southern garden leafhopper, *Empoasca solana,* often occurs in large numbers on sugar beets in the Imperial Valley and later moves to young cotton plants. The bright green adults are about $\frac{1}{8}$ inch long, and jump or fly readily when disturbed. The wingless nymphs are also bright green and characteristically move sideways when disturbed.

Both adults and nymphs feed on the lower surfaces of leaves where they suck out plant juices. Large numbers of feeding leafhoppers cause cotton leaves to take on a rough, leathery appearance with knotty veins. Other symptoms are cupping of the leaves and yellowish mottling which may develop into reddening on the margins in the later stages. The result of this injury is a stunting of small plants, but on older plants a rapid vegetative growth occurs when squares fail to set and small bolls are shed. Chemical control of leafhoppers is recommended if populations are heavy, nymphs are present, and the leaves are beginning to show yellow mottling and a leathery appearance.

Mites. The Atlantic mite, *Tetranychus atlanticus,* and another species, *Tetranychus cinnabarinus,* are the most common mites on seedling cotton in the lower desert valleys. These mites are very small and difficult to see without the aid of a magnifying glass. Normally, they occur on the lower leaf surfaces. Atlantic mites are straw-colored or slightly greenish and can cause rapid and severe defoliation of the cotton plants. Females of *T. cinnabarinus* are brick red in color, and the leaves damaged by them hang on the plants.

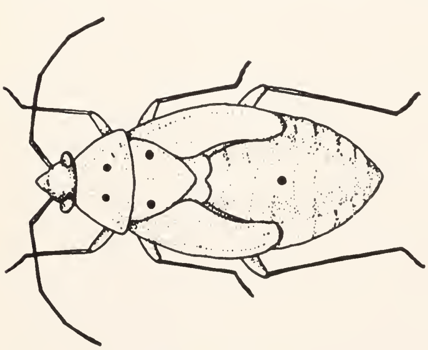
The first symptom which usually indicates the presence of the Atlantic mite on cotton is a dark reddish spot on the upper surface of the leaf or cotyledon

directly opposite the mite colony. Later the leaf may become slightly cupped in the area of the colony, and the plant will take on a dusty or dirty appearance as a result of dust collecting in the webbing produced by the mites. Severe infestations can result in stunting of the plants or even defoliation. Feeding of large numbers of *T. cinnabarinus* mites causes a stippling and yellowing of the leaves.

Although mites commonly appear on seedling cotton in this area, chemical control is rarely necessary. They are preyed upon by two very effective predators, the minute pirate bug, *Orius tristicolor,* and the six-spotted thrips, *Scolothrips sexmaculatus.* Both of these beneficial insects feed upon the mites and their eggs and will usually bring a mite population under control in the absence of chemical treatments.

Usually fields that develop a mite problem are those that have received repeated applications of insecticides. The upsurge in populations appears to result from destruction of natural enemies of the mites. Loss of these biological control agents can result in buildup of mites since both species have been shown to be resistant to organophosphorous compounds commonly used for control of mites.

Lygus bugs are among the most harmful of cotton pests in the low desert areas. Three species occur, but *Lygus hesperus* is believed to be the most important. Lygus bugs breed continuously throughout the year on alfalfa and other hosts. They attack cotton from the time the first squares appear.



Lygus bug nymph.

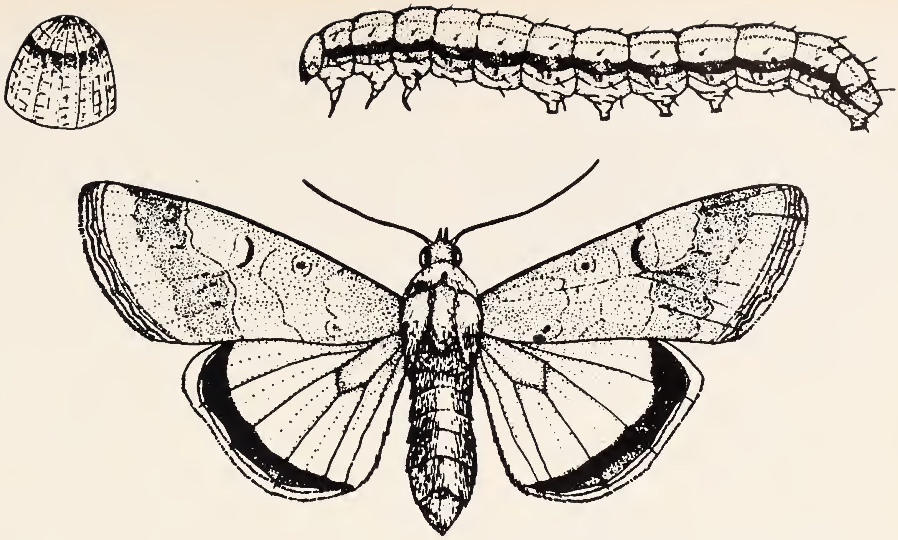
Lygus bugs are attracted to the more succulent growth where their feeding causes shedding of squares and young bolls. (A similar shedding often attributed to lygus bugs may be caused by poor cultural practices, adverse weather conditions, or a combination of these.) Other feeding damage is the development of bushy plants, rank growth, and deformed bolls, resulting in reduced quantity and quality of fiber.

Cotton grown in the vicinity of alfalfa hay fields may be subject to heavy populations of adult lygus bugs because of the movement of these insects from the hay when it is cut. Better control will be obtained if treatments are made following cutting of the alfalfa. Frequently, these populations do not remain in the cotton field into which they first migrate. If treatment is delayed for a few days, the population may move out, and an application of insecticide will not be necessary.

Fleahopper. A black fleahopper, *Spanogonicus albofasciata,* has become numerous in cotton in the Imperial Valley since 1958. Little is known of its life history, habits, etc., with respect to cotton, and evidence that its feeding causes economic injury to cotton is lacking. Research investigations are underway to determine if this insect is likely to become a serious pest of cotton.

The cotton bollworm, *Heliothis zea,* is one of the principal pests of cotton in the area. Bollworms can cause severe damage to squares, flowers, and small bolls if not detected and controlled early. Growers should check their fields very carefully at least twice a week for bollworms.

The adult bollworm is a night-flying moth that lays small, white eggs about the size of mustard seeds on terminal leaves and squares. One female moth can lay as many as 3,000 eggs. Bollworm eggs are pearly white when newly laid but may develop a purplish-brown band on the



Bollworm. Top left, egg showing characteristic dark band; top right, mature larva; lower, adult.

upper part in 1 to 2 days. The eggs are taller than wide and resemble tiny upside-down cups. They hatch in 2 to 4 days.

Young bollworms are cream or tan colored with conspicuous black spots each of which has a single hair. Fully grown worms are about 1½ inches long and vary in color from pale green or rose, to black. The sides and back are striped with light and dark bands.

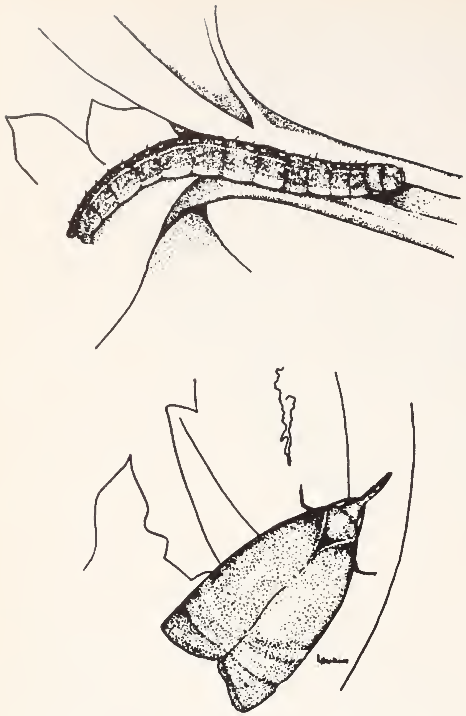
Young bollworms feed at first on the very small squares and terminal buds, and in the open flowers. They may also feed on the young, tender terminal leaves making them appear ragged. As the worms grow larger they move down the plant attacking larger squares and bolls. These older and larger worms may completely hollow out large bolls. A single bollworm may destroy from 8 to 14 squares and bolls during its development.

Chemical control measures should be taken when the bollworms are ½ inch or less in size. Larger bollworms are very difficult to kill with insecticides.

The leafroller, *Platynota stultana,* is the larva of a small brown moth. The female moth lays eggs in flat clusters or masses on the upper surfaces of the cotton leaves, usually on the newer leaves. The eggs overlap one another slightly like fish scales. They hatch in 3 to 5 days, each egg mass producing 50 to 100 small worms.

These tiny, yellowish-green worms with dark brown or black heads crawl over the plant, or they may drift on the wind to other plants by means of a thread-like web. A leafroller may form a "nest" by webbing the edges of a leaf together. Others settle inside the bracts at the bases of squares or bolls. Some feed on the terminal buds, even boring down into the stalk.

Egg cluster of leafroller.



Top, Mature larva of the leafroller;
lower, adult at rest.

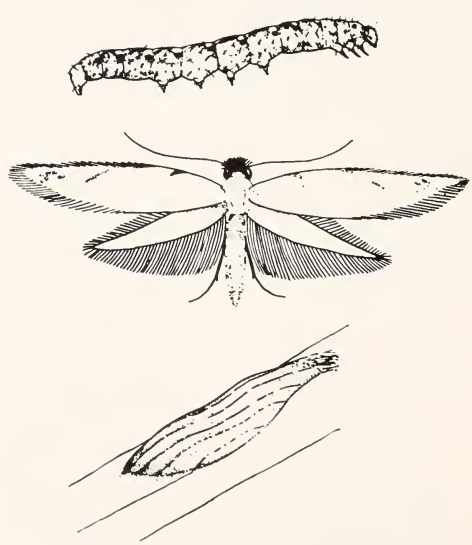
Leafrollers at times present a serious threat to cotton. They can cause severe damage to leaves, terminal buds, squares and small bolls. Large populations of leafrollers can cause excessive shedding of squares and small bolls. Injured bolls that do not drop may be destroyed later by boll-rotting organisms that enter through the scarred surface of the bolls.

Stink Bugs. The brown stink bug, *Euschistus conspersus* and Say's stinkbug, *Chlorochroa sayi*, attack cotton from mid to late season. The former species is by far the more abundant. Stink bugs are shield-shaped, relatively flattened insects. As its name implies, the brown stink bug is light brown or tan colored. The nymphs are oval-shaped and quite variable in color; the early stages do not closely resemble the adults. Stink bugs often migrate from alfalfa seed and sorghum fields to cotton.

Stink bugs injure cotton by inserting their beaks into the bolls and sucking the juices from the developing seed and other tissues. Many small bolls thus injured fall from the plant, but larger bolls remain and are often deformed. Feeding damage consists of shriveled seed and stained lint. Frequently, the locks become dry and hardened and cannot be harvested.

Cotton leaf perforator. Adults of this insect, *Bucculatrix thurberiella*, are white, slender moths about 1/8 inch long. The minute, oblong, yellow eggs are attached at the end to the leaves. Newly hatched perforators are leafminers and tunnel irregular courses through the leaf tissues. During later stages, they leave the mines and feed on the external surfaces of the leaves. During the molting period of the last two larval stages they are protected by a white, silken covering — the so-called "horseshoe stage." Visible perforator larvae are dull amber green with gray or black spots and lighter markings. When fully grown the larvae are about 3/16 inch long.

Cotton leaf perforators eat small, roughly circular "windows" or perforations in the leaves. Heavy populations may skeletonize the leaves to the extent



Cotton leaf perforator. Top down, mature larva, adult, and cocoon.

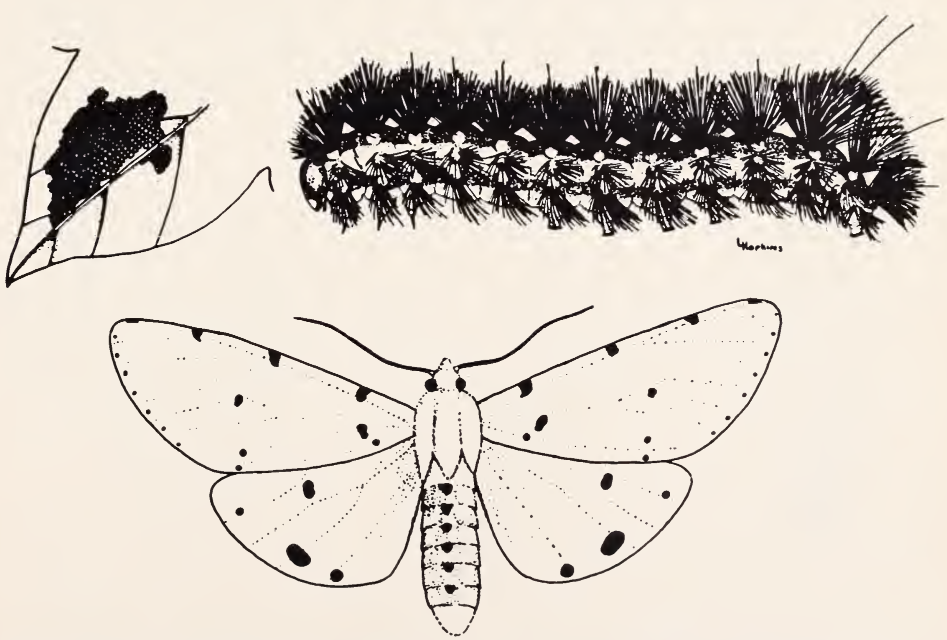
that severe defoliation takes place. When this occurs squares, flowers, and small bolls shed in excessive numbers, and larger bolls may open prematurely or suffer "sunburn." Perforators are a problem from mid to late season.

The Cabbage looper, *Trichoplusia ni,* is commonly found in cotton from mid to late season. Mature loopers attain a length of about 1 inch and vary in color from pale to dark green with faint stripes. These caterpillars have only two pairs of legs under the midsection of the body, and they move about with a characteristic looping gait.

Cabbage looper feeding causes ragged leaves, and severe infestations can defoliate the plants. Light to moderate looper populations in rank cotton actually benefit the crop by allowing sunlight and air to penetrate the dense foliage. This lowers the humidity and may reduce the incidence of boll rots. When looper numbers threaten excessive defoliation control is recommended.

Mature larva (top) and adult of the cabbage looper.

Salt marsh caterpillar. The adult female of the salt marsh caterpillar, *Estigmene acrea,* is a moth with a wing span of about $2\frac{1}{4}$ inches. The wings are white with small black spots. The abdomen is orange, banded with black. The male is similar in appearance but is smaller and has orange-colored hind wings. Eggs are laid in masses on many weeds and cultivated plants as well as on cotton. The larvae are at first light in color with long, darker hairs in clusters



The salt marsh caterpillar. Top left, egg cluster; top right, mature larva, botton, adult female.

For specific control . . .

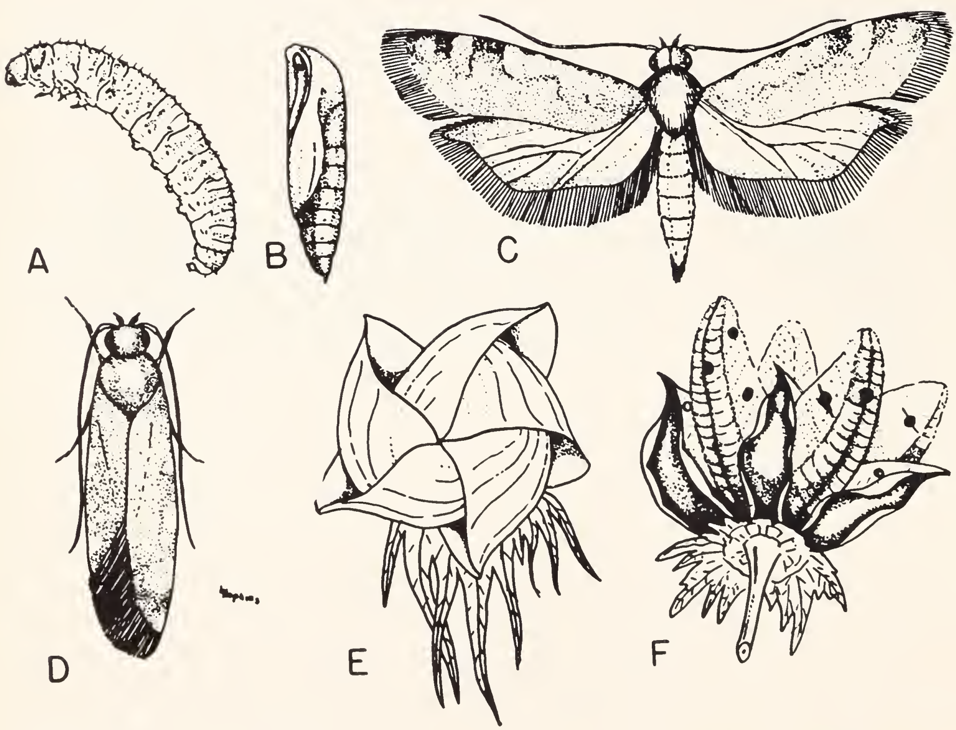
of pests attacking cotton see Leaflet 83. This leaflet is revised annually. Copies may be obtained from the local office of your University of California Farm Advisor or from Agricultural Publications, 207 University Hall, University of California, Berkeley 4.

covering the body. Mature "wooly worms" are approximately two inches long and are mottled yellow, orange, and black beneath a dense covering of long buff to black hairs.

For a short time after hatching, the young larvae feed in groups on the lower surfaces of the leaves. Older caterpillars feed independently and eat the leaves entirely. Heavy populations can completely defoliate the major portion of a field if not controlled.

The large green grasshopper, *Schistocerca venusta,* which is found in asparagus fields during most of the year, often migrates to adjacent cotton fields. The grasshoppers feed on leaves, occasionally on bolls, and they may chew on the woody stems causing the branches to break. Usually, insecticide applications for other pests will control these insects.

Pink bollworm. Although the pink bollworm, *Pectinophora gossypiella,* does not occur in California, it is of concern to cotton growers, particularly in the lower desert valleys. The pink bollworm is one of the most destructive pests of cotton in the world. It was introduced into Texas from Mexico in 1917 and has since been spreading slowly through the cotton belt in Oklahoma, Louisiana, Arkansas, New Mexico, and Arizona up to the border of



Pink bollworm. A—mature larva; B—pupa; C and D—adult; E—rosetted cotton blossom; F—open boll showing damage.

California. In spite of quarantines, infested material still moves from pink bollworm areas and constitutes a continual threat to California.

Its destructiveness is due to its habit of feeding on the cotton seeds within the boll, cutting lint fibers, staining lint, destroying seed, and allowing boll-rotting organisms to enter and completely destroy the boll. It is difficult to control with chemicals since the eggs are laid on the squares and bolls, and the larvae hatch and burrow directly into the tissue.

Adult pink bollworm moths emerge in the spring. The female lays 100 to 200 eggs singly or in masses of up to 20. The hatching larvae burrow into the squares or bolls and usually complete their development in 20 to 30 days. Several generations occur during the season.

General Pest Control Measures

Chemical Control

Insecticides and acaracides are among the most valuable aids to successful cotton production but must be used wisely to obtain maximum returns. Improper use can result in losses either to the crop directly or through excessive expenditures made necessary to remedy problems induced or intensified by earlier applications.

Insect and mite infestations change constantly within cotton fields. The aim of chemical pest control is to eliminate or reduce harmful populations before they do serious damage; therefore, *fields should be checked at least once a week.* The evaluation of insect and mite populations within a field is one of the most difficult jobs for the farmer. To do this properly the entire pest population must be taken into account as well as beneficial species. Only in this way can applications be timed correctly and unnecessary treatments eliminated or minimized. This is of importance financially; but, more important, unnecessary applications may cause outbreaks of other pests and accelerate the development of resistance.

When pesticides are necessary, they should be applied immediately, thoroughly, and at exactly the recommended dosage. Overtreatment may result in excessive harm to beneficial species, intensify residue problems, or injure the crop. Undertreatment will not give adequate pest control. Thoroughness of application cannot be overemphasized as untreated areas are sources of reinfestation. Drift of the insecticide can be minimized by treating in early morning or late evening when there is little air movement, and the best application conditions prevail. During hot periods morning treatments are usually more effective.

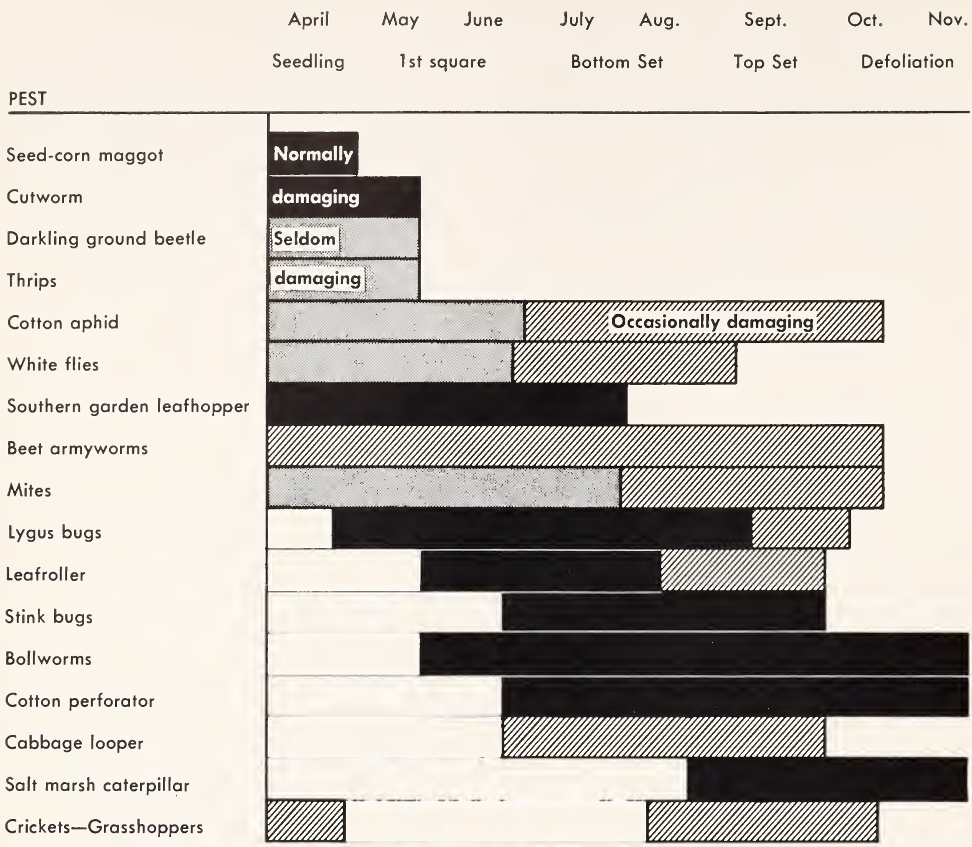
In general, sprays are preferred to dusts, but this will vary depending upon the chemical used, the pest involved, stage of growth of the crop, and the drift hazard. As recommendations are continually improving and changing, *specific* controls are not considered here.

Biological Control

This is natural or induced suppression of pests by beneficial organisms and includes encouragement or wise utilization of native and introduced parasites and predators, viruses, bacteria, and fungi.

The successful use of biological control in cotton is difficult, chiefly because of the wide range of pests involved, the rapidity with which many of them can increase to damaging levels, and the nature of the crop itself. Research is underway to increase our knowledge concerning biological control of cotton pests. Every effort should be made by growers to preserve beneficial species to take advantage of their usefulness. Growers should consult with the local Farm Advisor Office regarding special problems.

CALENDAR OF PEST PROBLEMS ON COTTON*



* This chart is based on usual conditions. Occasionally these insects occur in damaging numbers on other than the dates indicated.

Integrated Control

Integrated pest control makes the best use of both biological control factors and chemicals. When necessary, chemicals are employed to suppress pest populations below economic injury levels and at the same time beneficial species are preserved at levels sufficient to regulate pest populations. An important step toward integration is the development of selective pesticides which kill the pests but largely spare beneficial species.

Cotton is a difficult crop for which to develop integrated control. This is due to the wide range of pest species, relatively high dosages of chemicals necessary for their control, and the need to control some pests at low population levels. Some progress has been made; for example, most of the materials used for mite control are quite selective.

As parasites and predators are of far more importance than is generally realized, it is extremely important that pesticides be used only when necessary. This is particularly true early in the growing season. If little or no treating is necessary early in the season, beneficial species will often hold pest populations below damaging levels until mid season or later. Treatments for control of lygus bugs and leafhoppers most commonly upset biological control during this period. It is not suggested that treatments for these pests be omitted, but growers are urged to make certain that treatments

are timed correctly and applied only if absolutely necessary.

Supervised Control

Insect and mite infestations in cotton vary from field to field and from season to season. Unless fields are checked at least once a week, a severe outbreak of one or more pests may develop unnoticed by the grower.

If a farmer cannot check his own fields it is suggested that he enter a supervised control program. Under this system a grower obtains the services of a trained and experienced entomologist to follow the insect and mite populations and make recommendations concerning the control of pests. This helps to eliminate unnecessary treatments and chemical control measures are made more effective through better timing. The beneficial insect populations are also evaluated and full advantage is taken of those that are present. Control measures are tailored for the conditions prevailing in each field.

For further details of supervised control and the practicability of using it, the local Farm Advisor Office should be consulted.

DEFOLIATION

By P. H. van Schaik

As a result of changing economic conditions, the need to lower production costs, and difficulties encountered in obtaining hand labor for harvesting operations, considerable change in harvesting practices of cotton in the lower desert valleys has occurred in recent years. Mechanical harvesters have largely replaced hand pickers, and the use of preharvest defoliation is becoming a standard practice.

The long growing season and the almost completely distinct bottom and top crops make the use of bottom defoliation worth serious consideration. Removing the bottom leaves in rank cotton helps to reduce the excess humidity which delays boll opening and favors development and spread of boll-rotting organisms. Tests have shown bottom defoliation to reduce boll rots 60 to 70 per cent. This, in addition to better boll opening and greater picking ease, increased the bottom yield by 87 pounds of lint per acre.

Where lodging is a problem, bottom defoliation when the plants are still reasonably erect, may aid greatly in preserving the bottom crop. Removal of the bottom leaves under these conditions may also facilitate total defoliation prior to final harvest by allowing the top leaves to fall to the ground without becoming entangled with the bottom leaves.

In bottom defoliation, care must be taken not to direct the spray into areas of the plants where bolls are soft and immature. Application of defoliant to immature bolls prevents complete and normal development of fiber and, in severe cases, causes serious loss in yield and quality of the cotton. High-clearance ground machines with which spray can be applied at any height are used for bottom defoliation.

Some factors which determine the success or failure of the final complete defoliation are soil fertility, soil moisture, plant population, condition of the crop at time of defoliation, and weather. Late nitrogen applications or late irrigations are likely to cause vigorous growth or considerable regrowth after bottom defoliation. Actively growing leaves are usually impossible to defoliate. Uniform plant populations, preferably not too thick, lend themselves best to good de-

foliation. Unthinned stands or close spacings hamper penetration of defoliation sprays.

Time of defoliation varies widely with season and location. The condition of the crop is the only safe criterion to follow in making the decision. Bolls should be at least 30 days old to allow for complete development of the fiber. If a boll cannot be dented between thumb and forefinger or cannot be cut open easily with a knife, defoliation can usually be done without serious damage. This rule applies to bottom as well as total defoliation.

Boll development from bloom to open boll requires approximately 40 days in the early part of the fruiting season when temperatures are high. About 55 days are needed for the top crop to mature in October when temperatures are much lower. In a boll which requires 50 days from flower to open boll, the periods required for full development of individual properties are as follows:

	Days
Boll size (length)	18
Boll weight (dry)	45
Seed size (length)	18
Seed weight (dry)	45
Oil percentage of seed	42
Protein percentage of seed	45
Fiber length	18
Fiber strength	45
Fiber thickness (weight)	45

Data from USDA, ARS, Agriculture Handbook No. 178: W. H. Tharp, "The Cotton Plant, How It Grows and Why Its Growth Varies."

Most defoliants work best in warm weather because of the condition of the cotton plant and the speed with which its internal processes react with the absorbed material. Complete leaf drop takes considerably longer during cool weather. *Day temperatures below 70°F and night temperatures below 55°F are not favorable for good results.*

Where large acreages are to be harvested it is best to stagger defoliating operations so as not to be too far ahead of picking operations. Regrowth may cause considerable problems if defoliation is done too early in relation to harvest.

Most of the defoliation materials now used are essentially contact herbicides. At recommended rates they cause leaf drop, but at higher rates they dry the leaves, stalks, and bolls with little or no true leaf drop. Some types cause only rapid killing and desiccation of the plant tissues with slight or no defoliation even at the lower rates. These latter materials are the true desiccants. Desiccation is *not* defoliation; it results in trashy seed cotton requiring extra cleaning and ginning practices.

For additional specific information on materials, rates, and other recommendations regarding defoliation, the official Cotton Defoliation Guide published annually by the University of California is available at the local Farm Advisor Office.

HARVESTING

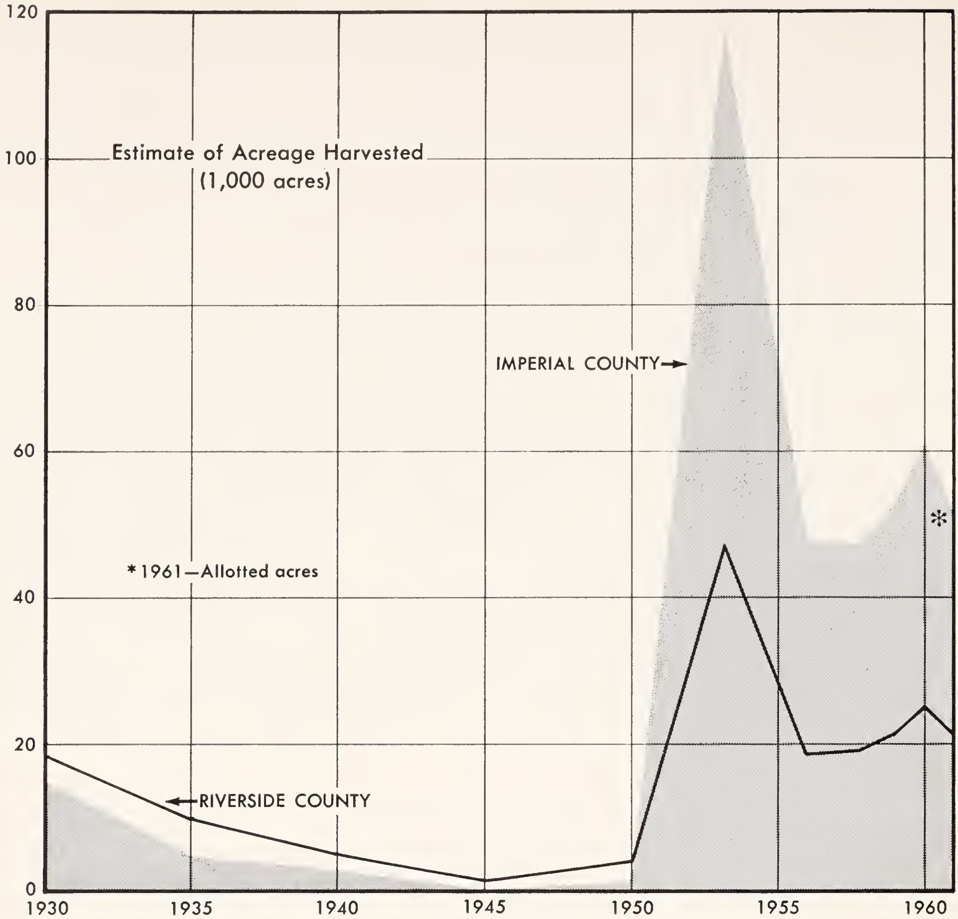
By P. H. van Schaik

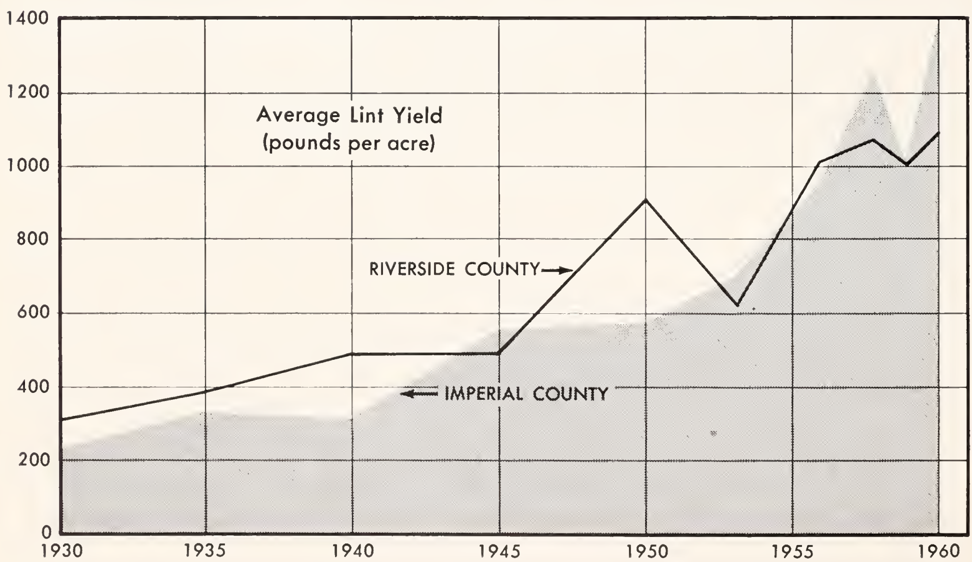
For years mechanical picking was limited to the top crop, but with the scarcity of hand labor, growers are looking for ways to harvest the bottom crop by machine as well. To do this successfully the following conditions must be met: Successful bottom defoliation at least 20 to 25 inches high on the plant; plants should be no taller than about 48 inches so that the machine will not damage the top crop; plants should be erect; the bottom crop should be well fluffed out and dry.

The most successful bottom picking has been done using conventional machines with all the spindles removed from the top 8 or 9 rows except a few which are left to move the plant tops through the machine. The bottom crop should be harvested as soon after bottom defoliation as possible. If picking is delayed, regrowth in the lower parts of the plants leads to considerable difficulties.

At present many growers do not attempt to harvest the bottom crop until after total defoliation in October and November. The amount of loss due to stringing of cotton out of the bur and fiber deterioration depends on varietal characteristics and seasonal climatic conditions such as winds and rains. Probably, even under the favorable weather conditions which normally prevail in the lower desert areas, some loss in fiber quality occurs as a result of exposure to moisture and sunshine.

Mechanical harvesting requires more preparation and planning than hand picking. The success of machine picking depends on such factors as field preparation, plant population, plant size, freedom from weeds and grasses, defoliation, maturity of crop, insect damage, and moisture. If stands are too thick, lodging is likely to be a serious problem; if plants are spaced too far apart fruiting branches and bolls may be too close to the ground.


Estimate of Acreage Harvested
(1,000 acres)
IMPERIAL COUNTY
RIVERSIDE COUNTY
*1961—Allotted acres
*
120
100
80
60
40
20
0
1930
1935
1940
1945
1950
1955
1960


Average Lint Yield
(pounds per acre)
RIVERSIDE COUNTY
IMPERIAL COUNTY
1400
1200
1000
800
600
400
200
0
1930
1935
1940
1945
1950
1955
1960

Large plants decrease picker efficiency and increase the seed cotton trash content. Grass is very easily picked up by the machine, is very difficult to remove from the lint, and can cause a reduction in grade.

Cotton should be dry when harvested. If damp it should be dried as soon as possible to prevent discoloration of the lint and loss in grade. Cotton should never be "tromped" in the trailer. Tromping retains moisture, pulverizes trash, and entangles the cotton; thus impeding efficient cleaning and ginning.

In fields where the bottom crop was left on the plants for a long period, scrapping, by machine or hand, may be economical. Generally this cotton is of inferior quality.

Ginning forms an important part of the harvesting operation of a cotton crop. The care and treatment cotton receives at the gin affect to a considerable degree the quality of the fiber and, therefore, the price a grower receives.

The following ginning program highlights the most important steps to follow for a successful ginning operation.

Use only enough drying for smooth ginning and proper cleaning.

- Five to 7 per cent lint moisture is best for quality preservation.
- Use moisture meter on lint slide samples to adjust drying.
- Adjust burners to provide desired temperature with minimum flame fluctuation.

Use only necessary seed cotton and lint cleaning equipment.

- Clean cotton requires minimum treatment.
- More cleaning is required for machine-picked cotton.
- Additional extracting is needed for snapped and machine-stripped cotton.
- By-passes are necessary to attain proper machinery selection.

Maintain uniform flow of seed cotton through the ginning system:

- To improve drying
- To improve cleaning
- To reduce overflow
- To increase capacity
- To reduce chokage

Maintain uniform loose rolls:

- For smooth preparation
- For better cleaning
- For less fiber damage
- For fewer neps
- For better spinning performance

Grouping seed cotton according to moisture and trash content is highly recommended as an essential part of this program for efficient and quality ginning.

The cotton classer's determination of grade and staple is an important step from the grower to the mill operator who is the final processor.

COTTON TIMETABLE

Time from planting to full emergence: average 10 days, but may range from 5 to 45 days.

Appearance of third leaf (first true leaf): approximately 10 days after emergence.

Appearance of second true leaf: 2–4 days after first true leaf.

Emergence to square: 35–50 days.

Square to white bloom: 21–23 days.

Bloom to open boll: 40 to 60 days, depending on temperatures, light, etc.

Approximately 35 per cent of blooms make bolls.

Heavy shedding begins with blooming peak.

Shedding is affected by internal conditions of plant, i.e., boll load, nutrition and moisture status and external conditions such as temperature and humidity.

Fiber length laid down first 18–22 days after blooming.

Fiber strength determined in second half of boll period. Mostly finished in 20–25 days.

Boll reaches full size in about 30 days.

October 1 is generally the last date for effective setting of fruit in a normal year.

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